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A typology of changes in Poland's population age structure between 2002 and 2022: A regional study

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Abstract. The study examines changes in the age structure of Poland's population by economic age groups (pre-working, working and post-working age, defined in Research materials and methods) between 2002 and 2022, including the subperiods 2002–2012 and 2012–2022, to determine spatial patterns at the national, regional and local levels. Typologies of these changes are developed, and the spatial autocorrelation of the results is established. All analysed data were obtained from Statistics Poland.
The age structure of Poland's population underwent significant and lasting changes in the period 2002–2022, with accelerated population ageing and altered spatial distribution of population age groups.

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Contents:

1. Introduction

Population change is directly related to variations in fertility, mortality and migration (Alho, 2008; Dörflinger & Loichinger, 2024; Mather et al., 2021). Among factors that influence population age structure, the long-term demographic processes altering the overall population composition are important, as well as the "age wave" (Bloom & Canning, 2008: 21), understood as baby booms alternating with baby busts (cf. Frątczak, 2002).

Non-demographic factors also play a vital role in population change and population composition. These factors encompass a broad spectrum of influences, such as the attractiveness of locations measured by employment opportunities, economic and social living conditions, poverty rates, the quality of public infrastructure, road accessibility, access to local amenities and services, housing availability, distance from larger cities, pollution levels, and environmental degradation (see Kotowska et al., 2008; Goldstein, 2009; Chi & Ventura, 2011a, 2011b; Willekens, 2015; Alvarez-Diaz et al., 2018; Buresch et al., 2024; Merino & Prats, 2020; Sobczak et al., 2020; Wichowska, 2023).

Demographic and non-demographic factors are known to interact in the short and long term. For instance, economically attractive areas that draw more new young residents tend to have relatively higher fertility rates and slower-ageing populations than those affected by persistent depopulation.

Prolonged population loss and changes in the population age structure, including progressive population ageing, have many detrimental consequences for both the economy and society. In particular, these challenges include a shrinking and increasingly ageing workforce, the working-age population having to economically support an increasing number of post-working-age people, growing demand for social and medical care services among the elderly, rising costs of healthcare and pensions, declining entrepreneurial and investment activity, and unfavourable transformations of the settlement network and spatial infrastructure, such as the closure of public facilities (see Szukalski, 2017, 2019, 2024; Anacka et al., 2018; Jaźwińska & Kiełkowska, 2018; Szweda-Lewandowska, 2022; Siskova et al. 2023; Wyszkowska & Wyszkowski, 2023; Sobolewska-Poniedziałek, 2024; Broniatowska & Strawiński, 2025; Przybyłka 2025).

In Poland, the first decades of the 21st century have brought significant and enduring changes in demographic structures and processes, which have reduced the total population size and accelerated its ageing. The effects of these changes have varied between urban and rural areas and across regions. Population decline has been particularly noticeable in areas with lower levels of social and economic development, including peripheral locations distant from major urban centres, as well as in many towns and cities. At the same time, most rural areas surrounding cities have experienced population growth, driven mainly by positive net migration associated primarily with suburbanisation and relatively higher fertility levels than in urban areas (see Kantor-Pietraga, 2014; Majdzińska, 2018; Szukalski, 2019; Kurek, 2025).

According to census data, in 2021, Poland had a population of 38.04 million, i.e., 0.5% and 1.2% smaller compared to 2002 and 2021, respectively. Notably, while the urban population decreased by 3.6% over the study period, the number of rural residents increased by 4.6%. The percentage of children aged 0–14 fell over that period by 2.5 percentage points (to 15.6% in 2021), while the share of people aged 65 and over increased by 5.9 percentage points (to 18.6% in 2021). In absolute terms, the number of children decreased from 6.94 million in 2002 to 5.94 million in 2021 (a 14% decline), while the elderly population increased in size from 4.85 million to 7.09 million (a 46% increase).

Consequently, the number of older individuals per 100 children rose from 70 in 2002 to 120 in 2021. Statistics Poland projections forecast a further decline in total population to ~37 million in 2030 and ~35.3 million in 2040. The shares of children aged 0–14 and those aged 65 and over in 2040 are expected to be 12.3% and 24.6%, respectively, indicating that the older subpopulation will be twice as large as the younger one.

The decline in Poland's population and changes in its age structure were mainly caused by persistently low fertility (*Note* 1). Between 2002 and 2022, the total fertility rate (TFR) ranged from 1.2 to 1.4, so it was wholly insufficient for successive cohorts of children to replace the generations of their parents. The mortality rate remained relatively unchanged between 2002 and 2019, before increasing during the 2020–2021 period due to the COVID-19 pandemic. At the local level, migration was a significant driver of population change.

Among the drivers of changes in the population age structure in the period under study, the "age wave" effect was significant. By 2002, those born during Polands baby booms of the 1950s and 1980s , who constituted a significant portion of the working-age population, reached the ages of 40–49 and 20–29, respectively. In the vast majority of cases their age ranges as of 2022 were 60–69 and 40–49, respectively, meaning that the older baby boomers entered the post-working age population, contributing to its growth. Within the next ~20

years, people born in the 1970s and 1980s will also reach retirement age, significantly increasing the percentage of the older population (Fig. A1 and Fig. A2 in the Appendix).

Demographic trends observed in Poland, particularly progressive population ageing (mainly caused by persistently low fertility rates) and population decline, are also occurring in many other European countries, especially those in post-communist states (see, e.g., Fihel & Okólski, 2019; Potančoková et al., 2021; Newsham et al., 2022; Truskolaski & Bugowski, 2022; Kurek, 2023; Majdzińska, 2024; Szafranek-Stefaniuk, 2024; Pinkus & Ruer, 2025).

Changes in the age composition of the Polish population, including its ageing, are well covered in the literature (see, e.g., Kurek, 2008; Wiśniewski et al., 2016; Fihel, 2018; Kurek et al., 2021, 2023; Urbaniak et al., 2021; Kuropka & Krupowicz, 2025). This study contributes to the existing body of research by providing an updated and in-depth examination of changes in regional and local populations conducted using several analytical methods.

The primary aim of the study was to identify regional differences in changes in the sizes and percentages of economic age groups in Poland between 2002 and 2022, including subperiods 2002–2012 and 2012–2022, and to create a typology of the changes. Selected results were examined for spatial autocorrelation. Additionally, a shift-share analysis of changes in the population age structure was also performed.

The study primarily examined relative changes in the sizes of economic age groups to identify real increases or decreases as potential indicators of their socio-economic impacts, including those on the labour market, healthcare, social care, and social security. The analysis also incorporated shifts in the population age composition that translate into long-term trends in demographic dependency. By employing both approaches, the study offers a more comprehensive understanding of how the age structure of populations living in Poland's regions and local areas changed between 2002 and 2022. This relatively broad perspective is the key strength of the study.

2. Research materials and methods

The analysis primarily examined three population age groups: pre-working age (0–17), working age (18–59 for women and 18–64 for men), and post-working age (60 and over for women and 65 and over for men – *Note* 2). The working age group was additionally subdivided into a mobile-age subgroup (18–44) and an immobile-age subgroup (45–59 for women and 45–64 for men).

The relative changes in the absolute numbers of economic age groups in the period from 2002 to 2022 (divided into the 2002–2012 and 2012–2022 subgroups) were examined at the regional and local levels using a dynamic index (index number) (see Equation below). By subtracting 100 from the index values, the percentage change was obtained, which was then analysed and presented in charts and maps.

$$i_{t_1-t_2} = \frac{P_{i_{t_2}}}{P_{i_{t_1}}} 100\%$$

where: P_i – the size of economic age group *i*; t_1, t_2 – the first (base) and last years of the period under consideration, respectively.

The analysis of the directions of changes (increases, decreases, and no change, with intensities disregarded) in the age structure of populations living in voivodeships and counties (voivodeships are Poland's top-level administrative regions, roughly equivalent to provinces; counties (poviats) are the administrative tier below them) identified six main types (*Note* 3) of change (Table 1). This main typology was extended to gain better insight into changes in the mobile and non-mobile age subgroups that comprise the working-age population; as a result, subtypes A, B, C and D were identified (Table 2).

Additionally, changes in the proportional structure of the population were examined by economic age group. This analysis only yielded four types of change (2, 3, 4 and 5) and two subtypes (C and D) (*Note* 4).

The spatial interactions of changes in the population size of age groups were evaluated by conducting a spatial autocorrelation analysis (*Note* 5) (see Anselin, 1988; Dube & Legros, 2014; Suchecki

Table 1. Main types of changes in the population age structure, 2002–2012, 2012–2022, 2002–2022

Type	The direction of changes in age groups		
	Pre-working age (0-17)	Working-age (18-59F/64M)	Post-working age (60+F/65+M)
1	↑	↑	↑
2	↑	↓	↑
3	↓	↑	↑
4	↓	↑	↓
5	↓	↓	↑
6	↓	↓	↓

Note: '↑' population growth; '↓' population loss; '–' no change
Source: author's elaboration based on Statistics Poland data

Table 2. Subtypes of changes in the working age groups, 2002–2012, 2012–2022, and 2002–2022

Subtype	Direction of changes in age groups	
	Mobile working age(18-44)	Immobile working age (45-59F/64M)
A	↑	↑
B	↑	↓
C	↓	↑
D	↓	↓

Note: see Table 1
Source: author's elaboration based on Statistics Poland data

& Olejnik, 2010), in which global and local Moran's I statistics, calculated using a first-order contiguity matrix of municipalities, were utilised.

Moran's I index tests a null hypothesis (H_0) that a given characteristic has a random spatial distribution versus an alternative hypothesis (H_1) stating that its distribution is non-random and that spatial autocorrelation is present. Generally, the local Moran's statistic (LISA --- Local Indicator of Spatial Association) identifies "the individual contributions to the global spatial autocorrelation. The objective of the statistics of local spatial autocorrelation is to verify whether, for a given observation i, it is surrounded by similar values to its own value, y_i or if, on the contrary, it is surrounded by values of the variable y_j that are far from its own value" (Dube & Legros, 2014: 77; see also: Dube & Legros, 2014: 80; Anselin 1988; Suchecki & Olejnik 2010: 120–125).

Using the shift-share analysis (SSA) framework (Suchecki & Antczak, 2010: 162–168) and data on the absolute numbers of economic age groups, demographic changes in Polish voivodeships between 2002 and 2022 were decomposed into those related to the age-structure effect (reflecting changes in the population's demographic composition) and those attributed to the regional-shift effect (associated with how the specific conditions of a voivodeship distinguish it from the national average). The two effects together constituted the total effect, indicating the difference between population growth in the country and in a given voivodeship.

The source of data on population sizes and age structure between 2002 and 2022 in the country, voivodeships, counties and municipalities was Statistics Poland.

3. Results

Between 2002 and 2022, Poland experienced a net population loss of 0.452 million. The urban population decreased by 1.081 million, while rural areas recorded an increase of 0.629 million. The absolute sizes of the economic age groups changed significantly over these two decades (Tables A2 and A3; see the Appendix): the pre-working age group decreased from 8.66 million to 6.95 million (by 19.8%) and the working age group from 23.79 million to 22.17 (6.8%); at the same time, and the post-working age group grew from 5.77 million to 8.65 million (50%).

Significant changes within the working-age population were also observed (Table A4 in the Appendix). While its mobile working-age component decreased in the period under study from 15.3 million to 13.6 million (11%), the non-mobile working-age group increased from 8.5 million to 8.6 million (0.7%).

The pre-working-age population decreased the most in the Opolskie, Świętokrzyskie, Warmińsko-Mazurskie, and Lubelskie voivodeships, while increasing in the urban areas of the Mazowieckie voivodeship and rural areas of the Pomorskie voivodeship. In most voivodeships, the working-age population – representing a potential labour resource – decreased between 2002 and 2022 (with voivodeships varying strongly in the direction and intensity of changes in the absolute size of the mobile and non-mobile age groups). The post-working-age population expanded in all voivodeships; in most, the increase was greater in the urban areas (Table A3 in the Appendix).

Following changes in the sizes of these subpopulations, the proportional age structure of Poland's population also changed significantly (Figs. A1 and A2, and Tables A2, A3 and A4 in the Appendix). The share of the pre-working-age and working-age groups decreased in all voivodeships, in contrast with the post-working-age population. In many voivodeships, changes in the proportions of these age groups differed between urban and rural areas.

The spatial distribution of age groups changed between 2002 and 2022 at both the county and municipal levels (Fig. 1 and Fig. A3 in the Appendix). In 2002, the northern, north-western and southern parts of Poland had higher percentages of pre-working age groups and lower percentages of post-working age groups; in most voivodeships, the percentages of pre-working age groups were higher in the peripheral areas than elsewhere. Municipalities adjacent to large cities had younger populations compared to large cities. In 2022, the population age structure was more favourable, mainly in municipalities around large cities, which also had a smaller percentages of the older population. In most voivodeships in 2002, the share of the working-age population was greater in large cities than in nearby municipalities; by 2022, this pattern had reversed.

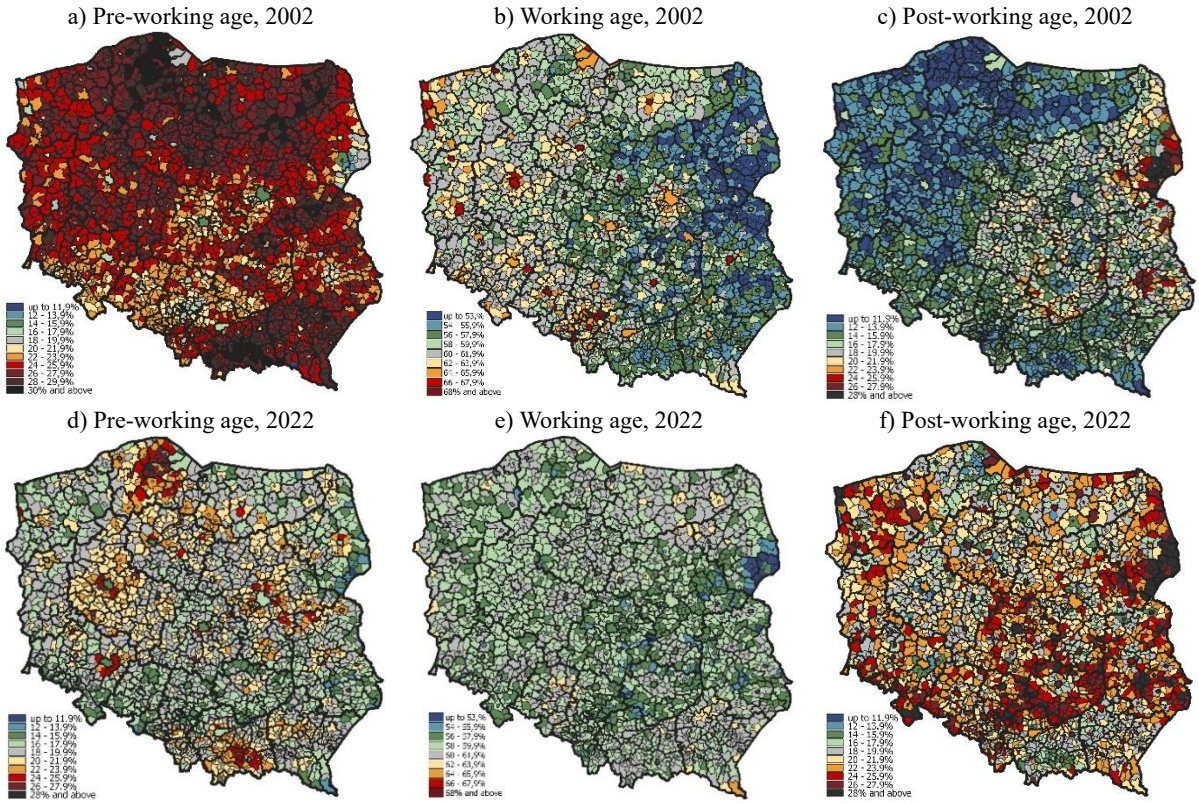

Fig. 1. Pre-working, working and post-working age populations in municipalities, 2002 and 2022 (%)
Source: author's elaboration based on Statistics Poland data

A comparative analysis of relative changes in age group sizes shows that 67% of municipalities and 73% of counties experienced a total population loss between 2002 and 2022; these proportions were higher in the period 2012–2022 than in 2002–2012. In the first subperiod, the pre-working age group decreased in almost all counties and municipalities; in the second subperiod, the vast majority of counties and municipalities recorded decreases in the working-age group and increases in the post-working age group (Table 3).

The spatial distribution of changes in the sizes of age groups was significantly different between 2002–2012 and 2012–2022 (Fig. 2 and Fig. A3 in the Appendix). The changes between 2002 and 2022 were relatively most favourable in municipalities

Table 3. Numbers and percentages of Polish counties and municipalities by type of population size change, 2002–2012, 2012–2022 and 2002–2022

Age group	Type of change	Counties			Municipalities		
		2002–2012	2012–2022	2002–2022	2002–2012	2012–2022	2002–2022
Total	Loss	181 (47.6%)	312 (82.1%)	278 (73.2%)	1169 (47.2%)	1844 (74.4%)	1667 (67.3%)
	Growth	199 (52.4%)	68 (17.9%)	102 (26.8%)	1307 (52.8%)	633 (25.6%)	809 (32.7%)
	No change	0	0	0	0	0	0
Pre-working	Loss	368 (96.8%)	309 (81.3%)	353 (92.9%)	2370 (95.7%)	1886 (76.1%)	2259 (91.2%)
	Growth	12 (3.2%)	71 (18.7%)	27 (7.1%)	106 (4.3%)	589 (23.8%)	217 (8.8%)
	No change	0	0	0	0	2 (0.1%)	0
Working	Loss	75 (19.7%)	354 (93.2%)	295 (77.6%)	257 (10.4%)	2179 (88.0%)	1604 (64.8%)
	Growth	305 (80.3%)	26 (6.8%)	85 (22.4%)	2216 (89.5%)	297 (12.0%)	869 (35.1%)
	No change	0	0	0	3 (0.1%)	1 (0%)	3 (0.1%)
Post-working	Loss	18 (4.7%)	0	0	613 (24.8%)	89 (3.6%)	221 (8.9%)
	Growth	361 (95.0%)	380 (100%)	380 (100%)	1855 (74.9%)	2387 (96.4%)	2254 (91.0%)
	No change	1 (0.1%)	0	0	8 (0.3%)	1 (0%)	1 (0%)

Source: author's elaboration based on Statistics Poland data

surrounding large cities, mainly because of increases in the pre-working and working age groups.

Moran's I statistics calculated for changes in the pre-working, working, and post-working age groups between 2002 and 2022 were 0.43, 0.26 and 0.48, respectively (0.43, 0.20 and 0.41 for 2002–2012 and 0.44, 0.34 and 0.53 for 2012–2022). This points to a positive and statistically significant ($p<0.001$ for all Moran's I statistics) global spatial autocorrelation of changes in the age structure of municipal populations. The distribution of changes is, therefore, non-random. A comparison of changes between the two subperiods also indicates that, in the working and post-working age groups, the spatial relationship between municipalities was stronger in the second subperiod.

Local Moran's I statistics revealed areas with municipalities where changes in the analysed age groups were statistically significantly similar throughout the entire study period. The red and dark blue colours in Fig. 3 represent areas with above-average changes (mostly large urban agglomerations) and minor changes in population, respectively. Municipalities where population changes showed significantly

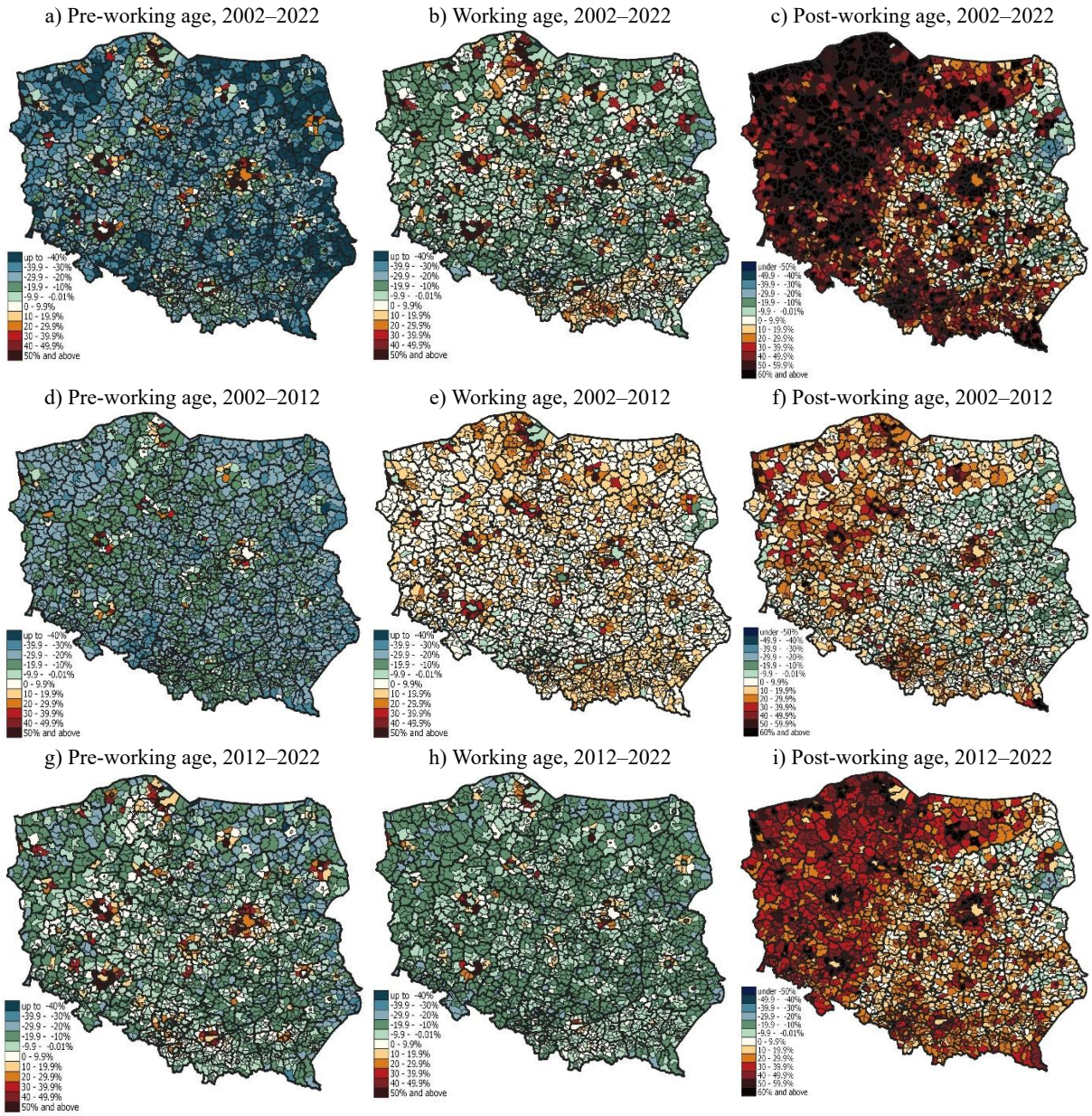

Fig. 2. Relative changes in pre-working, working and post-working age groups in municipalities, 2002–2022 (%)
Source: author's elaboration based on Statistics Poland data

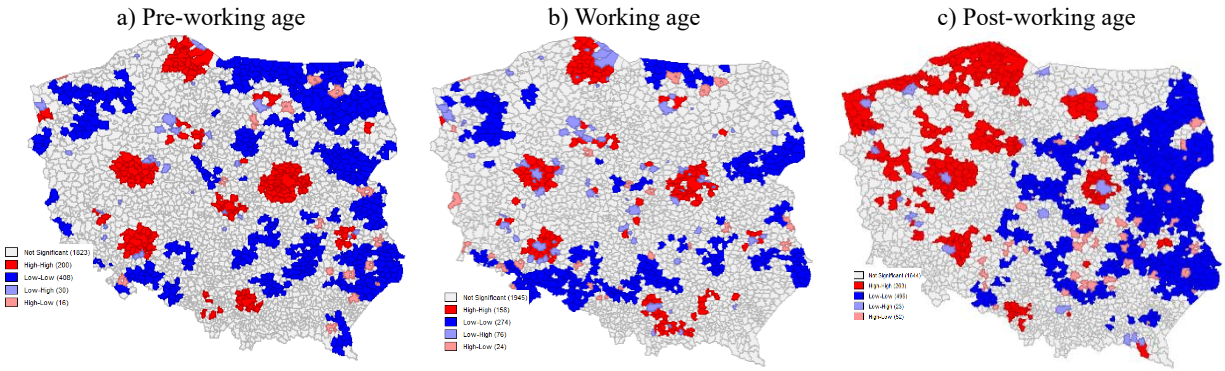

Fig. 3. Global and local spatial autocorrelations of changes in the sizes of pre-working, working and post-working age groups in municipalities, 2002–2022 (1st order connectivity)
Source: author's elaboration based on Statistics Poland data

Table 4. Numbers and percentages of counties in Poland by main type of population size change in the population age structure, 2002–2012, 2012–2022, 2002–2022

Type	Number and percentage of counties by type of change		
	2002–2022	2002–2012	2012–2022
1	26 (6.8%)	11 (2.9%)	26 (6.8%)
2	1 (0.3%)	1 (0.3%)	45 (11.8%)
3	59 (15.5%)	277 (72.9%)	0
4	0	17 (4.5%)	0
5	294 (77.4%)	72 (18.9%)	309 (81.3%)
6	0	2 (0.5%)	0

Source: author's elaboration based on Statistics Poland data

Table 5. Numbers and percentages of counties by subtype of population size change in the working age population, 2002–2012, 2012–2022, and 2002–2022

Subtype	Number and percentage of counties by subtype of change		
	2002–2022	2002–2012	2012–2022
A	33 (8.7%)	235 (61.8%)	17 (4.5%)
B	4 (1.1%)	2 (0.5%)	5 (1.3%)
C	191 (50.3%)	98 (25.8%)	47 (12.4%)
D	152 (40.0%)	45 (11.8%)	311 (81.8%)

Source: author's elaboration based on Statistics Poland data

different trends (marked in light blue and pink) mainly occurred in the central part of the country and some urban agglomerations.

Table 4 and Table 5 show the absolute numbers and percentages of counties with types and subtypes of changes in the age groups described in Tables 1 and 2. Type-5 changes were observed in 77% of counties between 2002 and 2022. This type of change also predominated from 2012 to 2022, superseding Type 3, which was common between 2002 and 2012. With regard to the subtypes, subtype A predominated from 2002 to 2012, and subtype D was prevalent between 2012 and 2022. In the entire 2002–2022 period, subtype C was representative of most counties.

The spatial patterns of changes in the age structure of Poland's population between 2002 and 2012 and between 2012 and 2022 were significantly different (Fig. 4). In urban areas, the pattern of changes was relatively stable in all three periods, with Type 5 dominating in most voivodeships. In rural areas, however, the population age structure changed in all voivodeships between the subperiods, becoming more similar to that in urban areas.

There were significant changes in the spatial distribution of age structures among counties' populations between 2002–2012 and 2012–2022 (Fig. 5 below and Fig. A3 and Table A1 in the Appendix). In both subperiods, there were 136 counties (accounting for 35.8% of all counties) that had the same type of changes. There was a relatively low consistency between the change typologies established for the subperiods (a Pearson's linear correlation coefficient of 0.41 [$p<0.05$]).

In relative terms, the most favourable pattern of change in the population age structure is that represented by Type 1. However, it was only found for a relatively small number of counties (although their number increased in the second sub-period), mainly in the residentially attractive suburbs of large cities, where the number of new residents exceeded the number of out-migrants (Fig. 5 and Table A5 in the Appendix). All Type-1 counties increased their total populations in the second subperiod (23 recorded growth in all years between 2012 and 2022, while 21 recorded annual increases from 2002 to 2022).

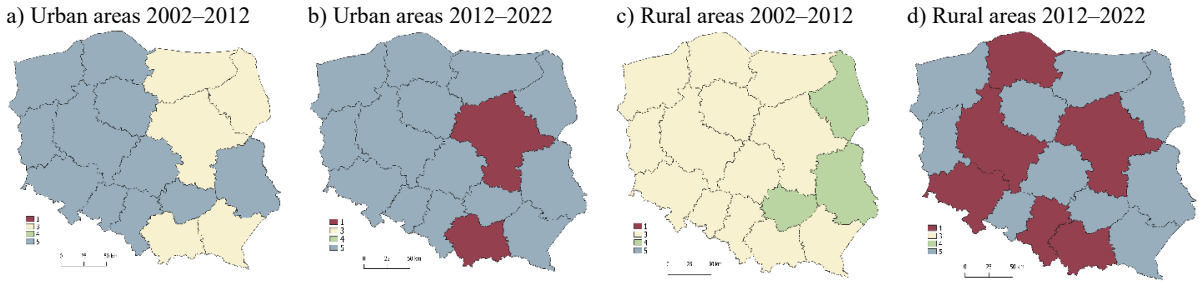

Fig. 4. Main types of changes in the population age structure by voivodeship (urban and rural areas), 2002–2012 and 2012–2022
Source: author's elaboration based on Statistics Poland data

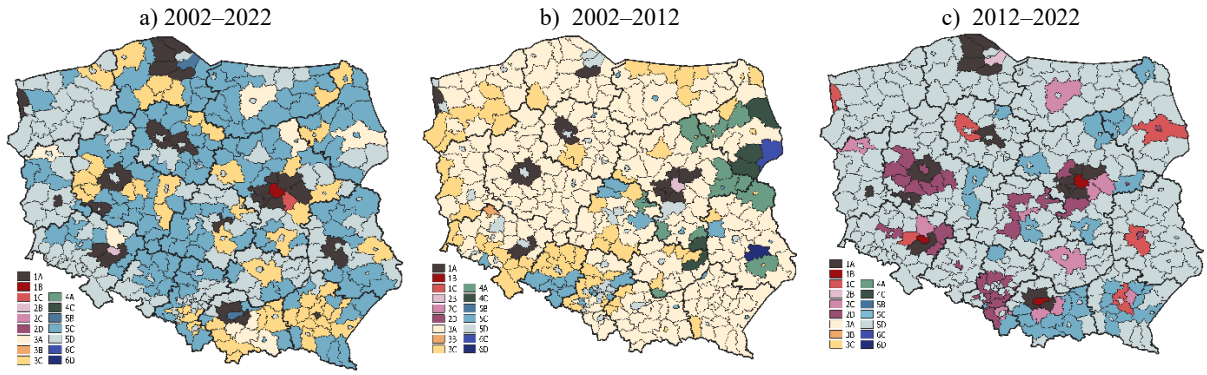

Fig. 5. The types and subtypes of changes in population age structure in counties, 2002–2022, 2002–2012 and 2012–2022
Source: author's elaboration based on Statistics Poland data

In the period 2012–2022, all counties with Type-1 changes saw an annual net migration increase, and nine recorded an annual natural increase (Fig. A5 and in the Appendix).

Most counties with Type-2 change between 2012 and 2022 had featured Type 3 in the previous subperiod. (These were mainly areas located in the vicinity of large cities.) Most experienced a natural decline from 2012 to 2022 and a population increase due to in-migration. (23 counties recorded a migratory population increase annually.) In the second subperiod, most counties with the Type-2 change were close to urban agglomerations, specifically around areas with the Type-1 change. They were also close to small and medium-sized towns, implying that an important driver of Type-2 change in areas could be suburbanisation. A closer look at the population age structure in counties with Type-2 change reveals their potential to increase their populations. The data show that the 40–49 age group grew in size in all those counties, most of which also recorded increases in the age groups 0–9, 10–19, 30–39, 60–69 and 70+ from 2012 to 2022.

In the 2002–2012 period, many counties that featured a Type-3 change in the population age structure disappeared over the next subperiod, becoming Types 1, 2 or 5. Counties that had Type-3 changes in the first subperiod were very diverse demographically.

From 2012 to 2022, Type-5 change predominated among counties. In the previous subperiod, 75% of these units had been classified as Type 3 and 19% as Type 5, while the remainder represented Types 4 and 6. Most counties with Type-5 change experienced population losses related to migration and natural decline in the 2012–2022 subperiod. Annual population decreases due to migration and natural decline occurred in 61% and 39% of counties, respectively. In the 2012–2022 period, 73% of Type-5 counties were subtype D for the working-age population.

In all or in the vast majority of counties classified as Type 5, the age groups 0–9, 10–19, 20–29, 30–39 and 50–59 decreased between 2012 and 2022, while the other age groups most often increased. Counties with Type-5 changes in the 2012–2022 period mainly occurred in the peripheries of voivodeships, far from

agglomerations and larger cities. However, they also occurred in some towns and cities.

Although only two counties in the first subperiod were Type 6 – one in the Podlaskie voivodeship and the other in Lubelskie – this type was common among many demographically old municipalities located in the centre and south of the Podlaskie Voivodeship and in the north and centre of the Lubelskie Voivodeship (*Note* 6) in all three periods.

The typology of changes in the proportional age structure of Poland's population, which largely reflects the impact of the progressing demographic ageing of the inhabitants (see Fig. A4 and Tables A6 and, –A7 in the Appendix), was created using the same approach. Most changes that occurred between 2002 and 2012 were Type 3; from 2012 to 2022, as well as in the entire analysed period, Type 5 was dominant. Among change subtypes, Subtype C was the most common in all periods under study (*Note* 7).

While both typologies of county population changes are essentially similar (Fig. 5 and A4), the first typology is spatially more varied than the second one. It revealed that, in many voivodeships, counties formed "ring-like" structures, with the most favourable types of change occurring in areas surrounding large cities and the least favourable in large cities and areas distant from urban centres. The second typology was more straightforward, as it clearly divided the country into a demographically older west and centre and a younger east.

The above observations were enhanced by conducting a shift-share analysis of changes in the population age structure between 2002 and 2022. It showed that differences among voivodeships were mainly due to the regional (spatial) effect rather than the structural effect, whose impact was significantly weaker in most voivodeships (Fig. 6). The total effect was positive for the Mazowieckie, Pomorskie, Małopolskie, Wielkopolskie and Dolnośląskie voivodeships, which means that the rates of their population growth exceeded the national average rate of 1.2% .

4. Summary and conclusions

Between 2002 and 2022, the age structure of Poland's population was affected by significant and enduring changes, which accelerated population ageing and altered the spatial pattern of the population age structure.

At the beginning of the 21st century, areas with the largest increase in the post-working age population had relatively high shares of children and working-age inhabitants and a relatively low share of older people. In areas that were already relatively demographically old, demographic ageing was the slowest. This pattern of changes largely reflects transformations in the population age structure and the "age-wave" effect.

Between 2002 and 2012, Type-3 changes predominated, while in the next subperiod, Type 5 became the most common. Type-1 changes, especially subtype A, are typical of areas in the vicinity of cities (especially large ones). Areas with Type-1 changes had a relatively more favourable situation regarding population growth than many other counties (most recorded annual gains in the long term), the birth–death ratio, net migration, and the percentage of older people. The least favourable changes were observed in the peripheries of the voivodeships. The typology of changes in the percentage age structure also pointed to Type 5 as the most common between 2002 and 2022, as well as between 2012 and 2022.

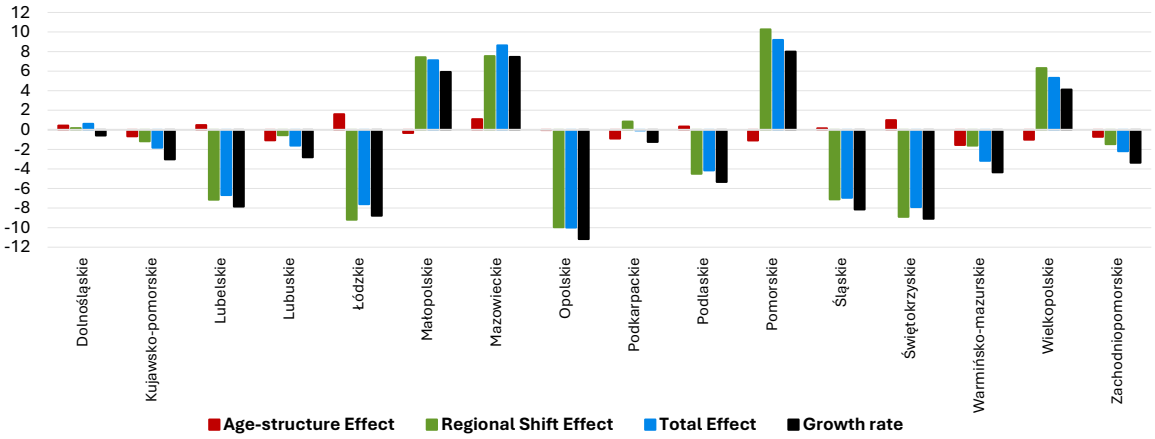

Fig. 6. Shift-share analysis of changes in population age structure by voivodship, 2002–2022 (in percentages)
Source: author's elaboration based on Statistics Poland data

Looking ahead, Type 5 changes (both in terms of the absolute size and the percentage of groups) are likely to dominate for at least the next two decades unless the retirement age limit is changed or extraordinary events take place that positively or negatively influence Poland's population. The number of areas with Type 1 population size change is also likely to increase as a result of population growth in suburban areas. The shift–share analysis, which identified the regional (spatial) effect as the main cause of changes in population sizes in all voivodeships between 2002 and 2022.

While the primary value of the typologies constructed is one of fundamental research, the information they contain also has a practical aspect. Its possible uses include support for regional and local governments in planning for education, labour market policies, and healthcare and social services, as well as infrastructure projects and spatial investments. In particular, they could assist authorities, public institutions and private sector entities in forecasting demographic needs and making investment decisions.

Notes

1. In the early 1990s, fertility remained only slightly below the replacement level (2.1 children per woman), whereas by the end of the decade it had fallen to ~1.4. Changes in family formation patterns that emerged in the late 1990s are largely interpreted through the lens of the Second Demographic Transition theory (Van de Kaa, 1987; Lesthaeghe, 2010). In Poland, the 1990s also marked the final stage of the demographic transition (Kirk, 1996), coinciding with the country's political and economic transformation. See also: Okólski, 1990, 2021; Kotowska, 1999, 2021; Kurek, 2011, 2023; Fihel, 2018; Fihel & Okólski, 2018; Walaszek & Wilk, 2022; Tymicki, 2025).
2. The typology only uses data on voivodeships and counties. The municipal data analysis offers greater spatial detail, but individual age groups in many municipalities are very small and therefore likely to lead to high indicator variability regarding population change, potentially leading to incidental conclusions. An overly detailed typology of changes may also make it more difficult to draw general conclusions and present spatial differences in a clear manner. Counties' populations are larger, rendering county data less susceptible to biases caused by random demographic fluctuations and inaccurate population records.
3. Different spatial units or varying periods for changes in the age structure of other (five-year or ten-year) age groups would yield a different typology of changes in Poland's population. Shorter periods or smaller age groups would produce more detailed results, but their use could prevent the identification of broader demographic trends.
4. It was not possible to obtain Types 1 and 6, or Subtypes A and D, in the second typology because the percentages of age groups must add up to 100%. Therefore, it is unlikely for all of them to increase or decrease at the same time.
5. The possibility of spatial autocorrelation was only considered for municipalities on the grounds that demographic processes are very local.
6. Most of these municipalities have experienced depopulation for several decades (see, inter alia, Eberhardt, 1989; Majdzińska, 2018), resulting in many of them being termed "problem areas" by Śleszyński et al. (2019).
7. As subtype C occurred in more than 90% of counties and B in the other 10%, the typology of subtypes was omitted from the maps (Fig. A4 in the Appendix).

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Appendix

Table A1. Counties by type of change in population age structure, 2002–2012 and 2012–2022

		2012–2022						Total
		1	2	3	4	5	6	
2002–2012	1	11	0	0	0	0	0	*11*
	2	1	0	0	0	0	0	*1*
	3	11	34	0	0	232	0	*277*
	4	0	1	0	0	16	0	*17*
	5	3	10	0	0	59	0	*72*
	6	0	0	0	0	2	0	*2*
Total		**26**	**45**	**0**	**0**	**309**	**0**	**380**

Source: author's elaboration based on Statistics Poland data

Table A2. Population structure by economic age groups in Poland and voivodeships in 2002 and 2022 (in %)

	Pre-working						Working						Post-Working					
	2002			2022			2002			2022			2002			2022		
	T	UA	RA	T	UA	RA	T	UA	RA	T	UA	RA	T	UA	RA	T	UA	RA
PL	22.7	20.6	26.0	18.4	17.0	20.4	62.2	64.7	58.4	58.7	58.0	59.7	15.1	14.8	15.6	22.9	25.0	19.8
DL	21.0	19.5	24.8	17.4	15.9	20.3	63.7	65.0	60.7	58.8	58.2	60.0	15.3	15.6	14.5	23.9	25.9	19.7
KP	23.4	21.3	26.9	18.3	16.5	20.7	62.5	64.4	59.4	58.6	57.6	60.0	14.1	14.3	13.7	23.1	25.9	19.2
LU	23.8	22.3	25.1	18.0	16.9	19.0	60.0	64.7	55.8	58.1	57.0	59.1	16.2	13.0	19.0	23.9	26.1	21.9
LB	23.4	21.9	26.1	18.2	17.3	19.8	63.3	64.8	60.4	58.6	57.6	60.2	13.3	13.3	13.4	23.2	25.0	20.0
LD	20.6	18.8	23.8	17.3	15.9	19.5	62.4	64.8	57.8	57.3	56.4	58.7	17.1	16.4	18.4	25.4	27.7	21.9
MA	23.8	20.3	27.4	19.3	17.1	21.4	61.1	64.3	57.9	59.7	59.3	60.0	15.1	15.4	14.7	21.0	23.7	18.6
MZ	21.4	19.0	25.8	19.4	18.5	21.1	62.0	64.5	57.4	58.7	58.6	58.9	16.6	16.5	16.8	21.9	22.9	19.9
OP	22.1	21.0	23.4	16.6	15.8	17.6	62.8	64.9	60.5	59.4	58.0	61.0	15.1	14.1	16.1	23.9	26.2	21.4
PK	25.6	23.4	27.1	18.7	17.3	19.7	59.8	63.7	57.2	59.5	57.9	60.6	14.5	12.9	15.6	21.7	24.7	19.6
PD	24.1	23.7	24.8	18.2	17.8	18.9	59.5	63.3	54.1	58.9	58.8	59.1	16.3	13.0	21.1	22.9	23.5	22.0
PM	23.8	20.9	29.7	19.8	17.5	23.7	62.8	64.4	59.3	59.0	58.5	59.9	13.5	14.6	11.0	21.2	24.1	16.4
SL	21.0	20.2	23.9	17.4	16.7	19.7	64.2	65.2	60.5	58.2	57.9	59.3	14.8	14.7	15.6	24.4	25.4	21.0
SK	22.7	20.6	24.5	16.9	15.4	18.2	60.6	64.6	57.1	57.6	55.8	59.1	16.7	14.8	18.4	25.5	28.8	22.8
WM	25.0	22.9	28.2	18.3	17.3	19.9	61.9	64.0	58.7	59.1	57.9	61.0	13.1	13.1	13.1	22.5	24.9	19.1
WP	23.7	21.3	26.9	19.6	17.4	22.0	62.7	64.7	59.9	59.0	58.3	59.9	13.6	14.0	13.2	21.4	24.3	18.0
ZP	22.6	20.6	27.1	17.3	16.3	19.4	63.7	65.3	60.2	58.5	57.4	60.6	13.7	14.1	12.7	24.2	26.2	20.0

Source: Author's own elaboration based on Statistics Poland data

Note: Voivodeship designations (DS – dolnośląskie, KP – kujawsko-pomorskie, LB – lubuskie, LD – łódzkie, LU – lubelskie, MA – małopolskie, MZ – mazowieckie, OP – opolskie, PD – podlaskie, PK – podkarpackie, PM – pomorskie, SK – świętokrzyskie, SL – śląskie, WN – warmińsko-mazurskie, WP – wielkopolskie, ZP – zachodniopomorskie)

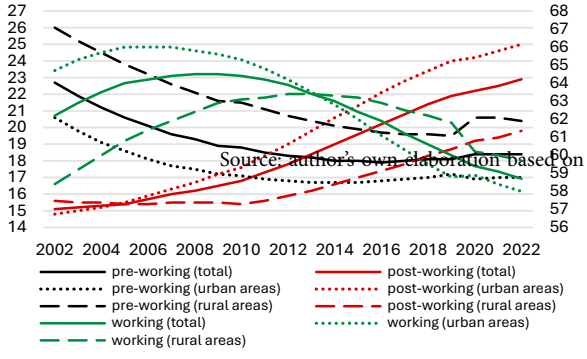

Fig. A1. Pre-working, working and post-working age populations in Poland, 2002–2022 (%)

Note: Pre-working and post-working age populations (left-hand scale) and working-age population (right-hand scale)

Source: author's elaboration based on Statistics Poland data

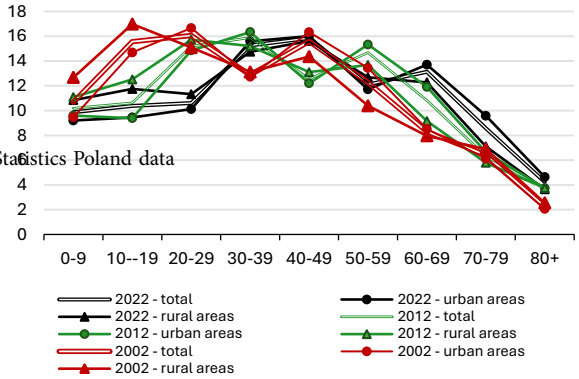

Fig. A2. The age groups of Poland's population, 2002, 2012 and 2022 (%)

Source: author's elaboration based on Statistics Poland data

Table A3. Changes in population size (in percentages and percentage points) by economic age groups in Poland and voivodeships in 2002–2022

	Pre-working age						Working age						Post-working age					
	in percentages			in percentage points			in percentages			in percentage points			in percentages			in percentage points		
	TOT	UA	RA	TOT	UA	RA	TOT	UA	RA	TOT	UA	RA	TOT	UA	RA	TOT	UA	RA
PL	-19.8	-21.0	-18.1	-4.3	-3.6	-5.6	-6.8	-14.4	6.7	-3.6	-6.7	1.4	50.0	61.3	32.7	7.8	10.2	4.2
DL	-17.8	-22.8	-8.0	-3.6	-3.5	-4.5	-8.3	-15.6	11.2	-5.0	-6.8	-0.7	55.4	56.5	52.7	8.6	10.3	5.2
KP	-24.3	-29.6	-17.4	-5.2	-4.8	-6.2	-9.0	-18.8	8.4	-3.9	-6.8	0.7	59.0	63.9	50.7	9.0	11.6	5.6
LU	-30.2	-30.7	-29.8	-5.8	-5.4	-6.1	-10.7	-19.6	-1.7	-1.9	-7.7	3.2	35.5	82.7	7.2	7.6	13.1	2.9
LB	-24.3	-23.3	-25.9	-5.2	-4.6	-6.3	-10.0	-13.9	-2.5	-4.7	-7.2	-0.2	69.2	82.3	45.5	9.9	11.7	6.6
LD	-23.4	-26.6	-18.7	-3.3	-2.9	-4.3	-16.2	-24.4	0.9	-5.1	-8.4	0.9	35.9	46.5	18.3	8.4	11.3	3.5
MA	-14.2	-15.3	-13.4	-4.5	-3.3	-6.0	3.5	-6.9	15.1	-1.4	-5.0	2.2	47.8	55.2	39.9	6.0	8.3	3.9
MZ	-2.4	4.7	-11.9	-2.0	-0.5	-4.6	1.7	-2.4	10.1	-3.3	-5.9	1.5	41.4	49.4	27.1	5.3	6.4	3.1
OP	-33.2	-32.8	-33.7	-5.5	-5.2	-5.8	-15.9	-20.0	-11.1	-3.4	-6.9	0.5	41.0	65.7	17.0	8.9	12.1	5.3
PK	-27.7	-25.6	-29.0	-6.9	-6.0	-7.4	-1.8	-8.8	3.6	-0.3	-5.8	3.4	47.7	92.2	22.7	7.2	11.8	4.0
PD	-28.7	-26.7	-31.4	-6.0	-5.9	-5.9	-6.3	-9.2	-1.5	-0.6	-4.5	5.0	32.8	76.7	-6.0	6.6	10.5	0.9
PM	-10.1	-17.2	0.6	-4.0	-3.5	-6.1	1.5	-9.8	27.7	-3.8	-5.9	0.7	70.0	63.4	88.4	7.7	9.4	5.4
SL	-23.6	-26.9	-13.0	-3.5	-3.5	-4.2	-16.7	-21.7	3.4	-6.0	-7.3	-1.2	50.8	53.1	42.5	9.5	10.8	5.5
SK	-32.4	-33.7	-31.5	-5.8	-5.3	-6.4	-13.5	-23.1	-4.4	-2.9	-8.8	2.0	38.6	74.1	14.6	8.8	14.1	4.4
WM	-29.8	-29.4	-30.3	-6.7	-5.7	-8.2	-8.6	-15.2	2.3	-2.7	-6.1	2.3	64.4	78.6	43.0	9.4	11.8	5.9
WP	-13.9	-21.4	-5.9	-4.1	-3.9	-4.9	-1.9	-13.3	14.9	-3.6	-6.5	0.0	63.2	67.8	56.6	7.7	10.4	4.8
ZP	-26.1	-25.0	-27.9	-5.3	-4.3	-7.7	-11.4	-16.6	1.5	-5.3	-7.8	0.4	71.5	76.4	59.0	10.6	12.2	7.3

Note: See Table A2
Source: Author's own elaboration based on Statistics Poland data

Table A4. The mobile-working and immobile-working age groups in Poland and voivodeships as percentages of the total working age population, and changes in their sizes (% and p.p.) between 2002 and 2022

	In relation to the total working-age population (%)		Changes in the population size (%)		Changes in the percentage structure (p.p.)			
	Mobile working age	Immobile working age	Mobile working age	Immobile working age	Mobile working age	Immobile working age	Mobile working age	Immobile working age
	2002		2022		2002–2022			
Polska	64.1	35.9	61.3	38.7	-11.0	0.7	-2.9	2.9
Dolnośląskie	62.6	37.4	62.2	37.8	-9.0	-7.2	-0.4	0.4
Kujawsko-pomorskie	64.2	35.8	60.4	39.6	-14.3	0.5	-3.8	3.8
Lubelskie	64.4	35.6	60.4	39.6	-16.3	-0.6	-4.0	4.0
Lubuskie	63.9	36.1	60.7	39.3	-14.6	-1.9	-3.3	3.3
Łódzkie	61.6	38.4	59.6	40.4	-18.9	-11.8	-2.0	2.0
Małopolskie	66.3	33.7	62.9	37.1	-1.8	13.9	-3.4	3.4
Mazowieckie	63.4	36.6	62.8	37.2	0.7	3.5	-0.6	0.6
Opolskie	65.5	34.5	58.5	41.5	-24.9	1.0	-7.0	7.0
Podkarpackie	66.9	33.1	61.2	38.8	-10.0	14.9	-5.6	5.6
Podlaskie	66.5	33.5	60.2	39.8	-15.1	11.1	-6.2	6.2
Pomorskie	64.6	35.4	62.9	37.1	-1.0	6.2	-1.6	1.6
Śląskie	63.1	36.9	59.4	40.6	-21.6	-8.3	-3.7	3.7
Świętokrzyskie	63.2	36.8	59.3	40.7	-18.7	-4.5	-3.8	3.8
Warmińsko-mazurskie	65.7	34.3	60.3	39.7	-16.1	5.8	-5.4	5.4
Wielkopolskie	64.9	35.1	62.4	37.6	-5.7	5.2	-2.5	2.5
Zachodniopomorskie	63.0	37.0	60.3	39.7	-15.2	-4.9	-2.7	2.7

Table A5. Numbers and percentages of counties in Poland by main type and subtype of change in the population age structure, 2002–2012, 2012–2022, 2002–2022

Type	2002–2022	2002–2012	2012–2022	Type	2002–2022	2002–2012	2012–2022
1A	11(2.9%)	24(6.3%)	17(4.5%)	3C	64(16.8%)	50(13.2%)	0
1B	0	1(0.3%)	3(0.8%)	4A	12(3.2%)	0	0
1C	0	1(0.3%)	6(1.6%)	4C	5(1.3%)	0	0
2B	1(0.3%)	1(0.3%)	2(0.5%)	5B	0	2(0.5%)	0
2C	0	0	11(2.9%)	5C	28(7.4%)	140(36.8%)	30(7.9%)
2D	0	0	32(8.4%)	5D	44(11.6%)	152(40.0%)	279(73.4%)
3A	212(55.8%)	9(2.4%)	0	6C	1(0.3%)	0	0
3B	1(0.3%)	0	0	6D	1(0.3%)	0	0

Source: author's own elaboration based on Statistics Poland data

Table A6. Numbers and percentages of counties in Poland by main type of change in the percentage population age structure, 2002–2012, 2012–2022, 2002–2022

Type	Number and percentage of counties by type of change		
	2002–2022	2002–2012	2012–2022
1	0	0	0
2	7 (1.8%)	1 (0.3%)	117 (30.8%)
3	84 (22.1%)	311 (81.8%)	0
4	0	11 (2.9%)	0
5	289 (76.1%)	57 (15.0%)	263 (69.2%)
6	0	0	0

Source: author's elaboration based on Statistics Poland data

Table A7. Numbers and percentages of counties by subtype of change in the percentage working age population, 2002–2012, 2012–2022, and 2002–2022

Subtype	Number and percentage of counties by subtype of change		
	2002–2022	2002–2012	2012–2022
A	0	0	0
B	14 (3.7%)	27 (7.1%)	19 (5.0%)
C	366 (96.3%)	353 (92.9%)	361 (95.0%)
D	0	0	0

Source: author's elaboration based on Statistics Poland data

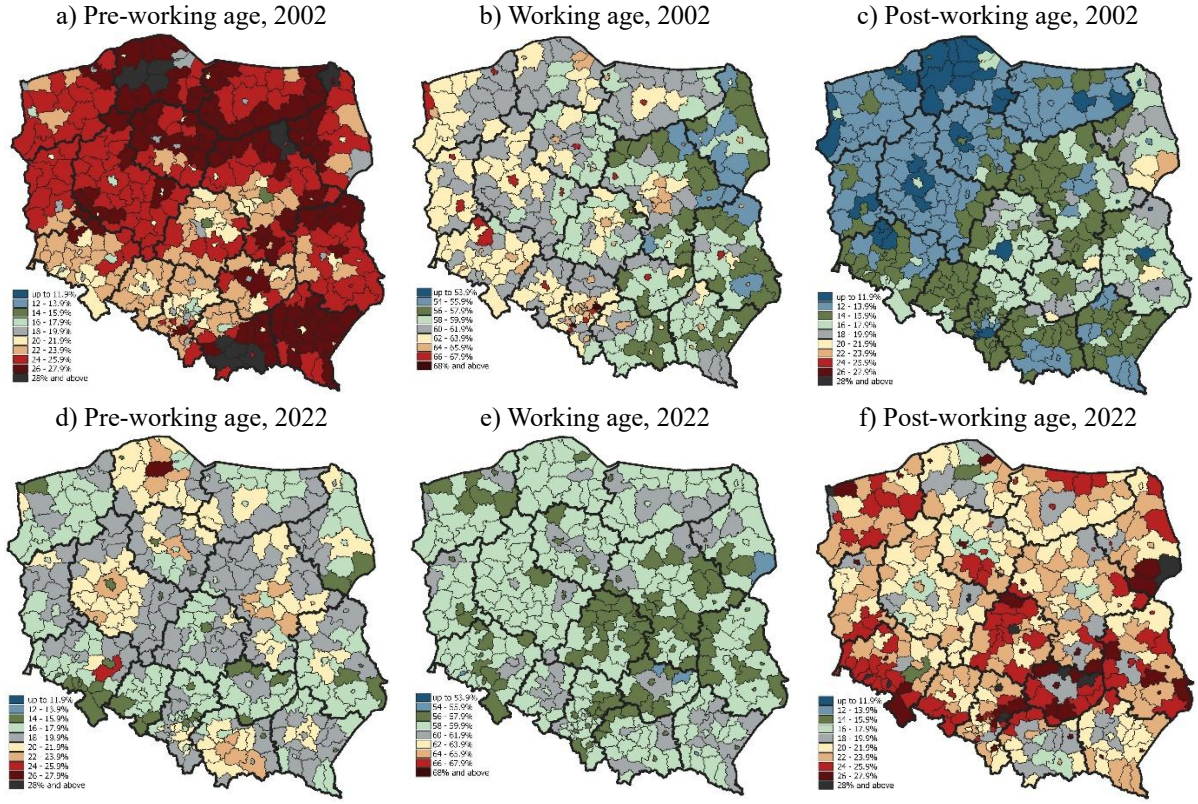

Fig. A3. Population at pre-working, working and post-working age in counties in 2002 and 2022 (%)
Source: author's own elaboration based on Statistics Poland data

Fig. A4. Types of changes in the percentage population age structure in counties, 2002–2022, 2002–2012 and 2012–2022
Source: author's own elaboration based on Statistics Poland data

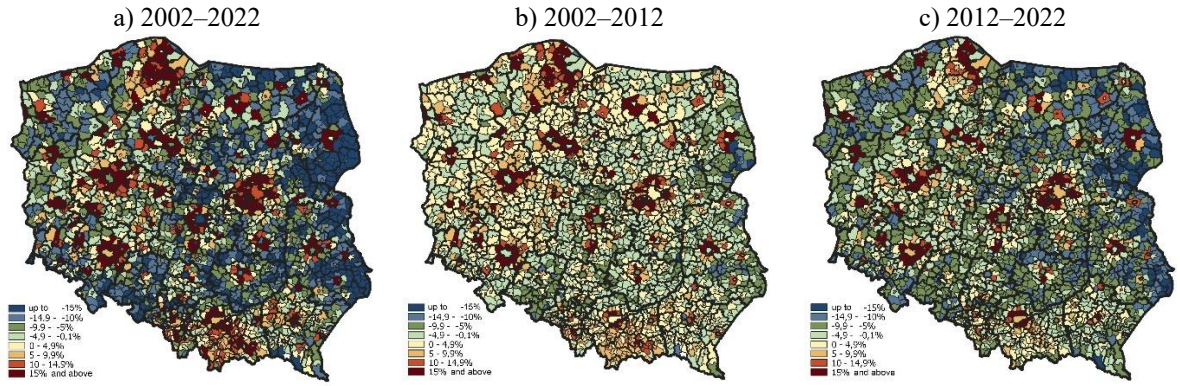

Fig. A5. Relative changes in total population size in municipalities, 2002–2022, 2002–2012 and 2012–2022 (%)
Source: author's own elaboration based on Statistics Poland data